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Title: Characterization of EJ-301 liquid scintillators

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Characterization of EJ-301 liquid scintillators

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Space Science and Applications
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Thomas Redpath (NEN-2)

- Educational Background
  - James Madison University, 2011
  - Central Michigan University, 2014
  - Michigan State University, present

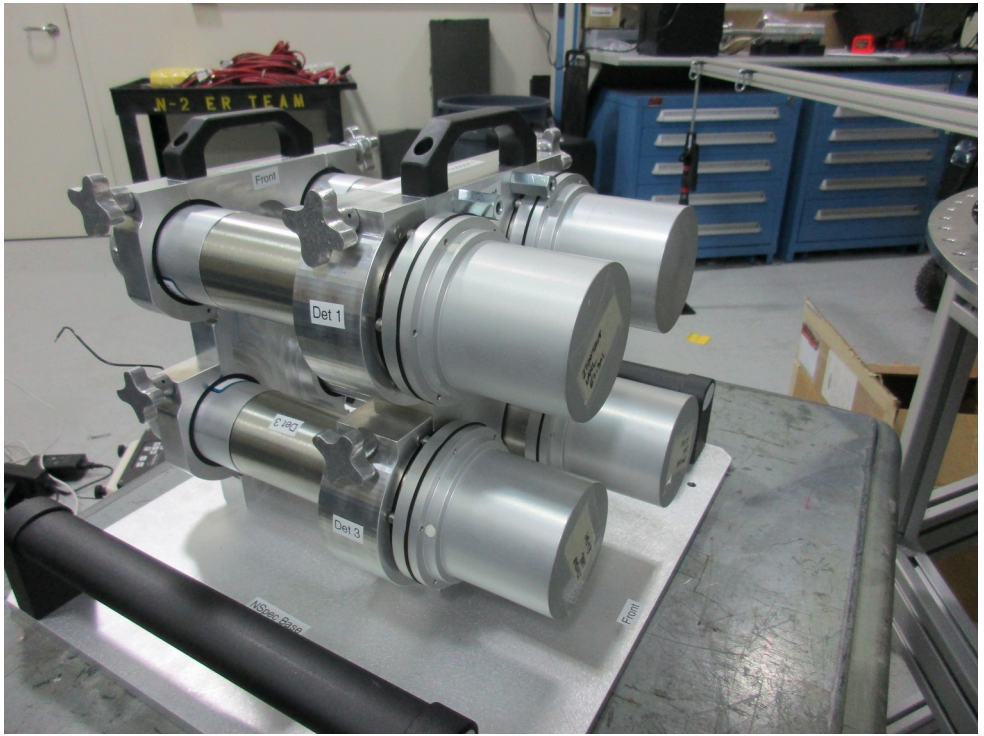
- Division: NEN
  - Group: NEN-2
  - Krista Meierbachtol




- Research
  - Characterization of liquid scintillators for nγ detection
  - Lifetime measurement of neutron-unbound ^{26}O

Research Overview and Motivation

- Compact and portable detectors for neutron spectrometry
- ID neutron sources (e.g. ^{240}Pu, ^{252}Cf)
- Streamline data acquisition and analysis
- Calibration with gamma sources
- Translate detector response into an energy spectrum – unfolding
- Accurate unfolding increases the sensitivity of assays performed on nuclear material

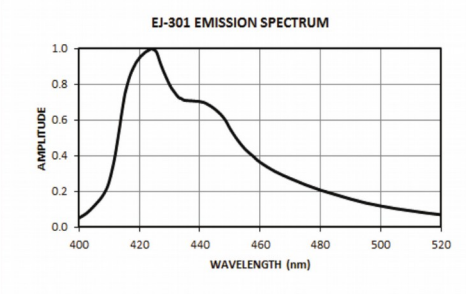


J.A. Mullens, J.D. Edwards, S.A. Pozzi, Analysis of scintillator pulse-height for nuclear material identification, in: Institute of Nuclear Materials Management 45th Annual Meeting, July 18–22, Orlando, FL, 2004.

Portable Detectors and Electronics

- **Four Eljen EJ-301 liquid scintillators, bubble-free**

PROPERTIES	EJ-301
Light Output (% Anthracene)	78
Scintillation Efficiency (photons/1 MeV e-)	12,000
Wavelength of Maximum Emission (nm)	425
Decay Time, Short Component (ns)	3.2
Mean Decay Times of First 3 Components (ns)	3.16 32.3 270
Bulk Light Attenuation Length (m)	2.5 - 3
Specific Gravity	0.874
Refractive Index	1.505
Flash Point (°C)	26
Boiling Point (°C at 1 atm)	141
Vapor Pressure (mm Hg, at 20°C)	6
H Atoms per cm³ ($\times 10^{22}$)	4.82
C Atoms per cm³ ($\times 10^{22}$)	3.98
Electrons per cm³ ($\times 10^{23}$)	2.27



PMT

Ej-301 scintillator

- **Caen DT5730 desktop digitizer**

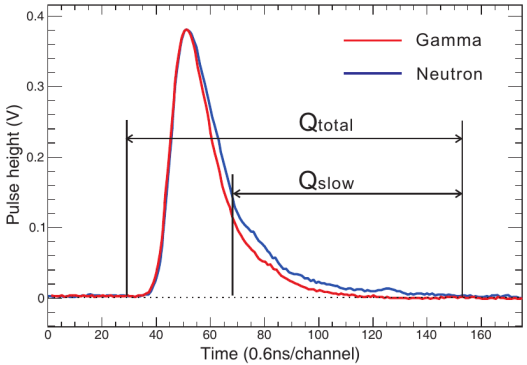
www.caen.it

- **Caen DT5533 High Voltage Supply**

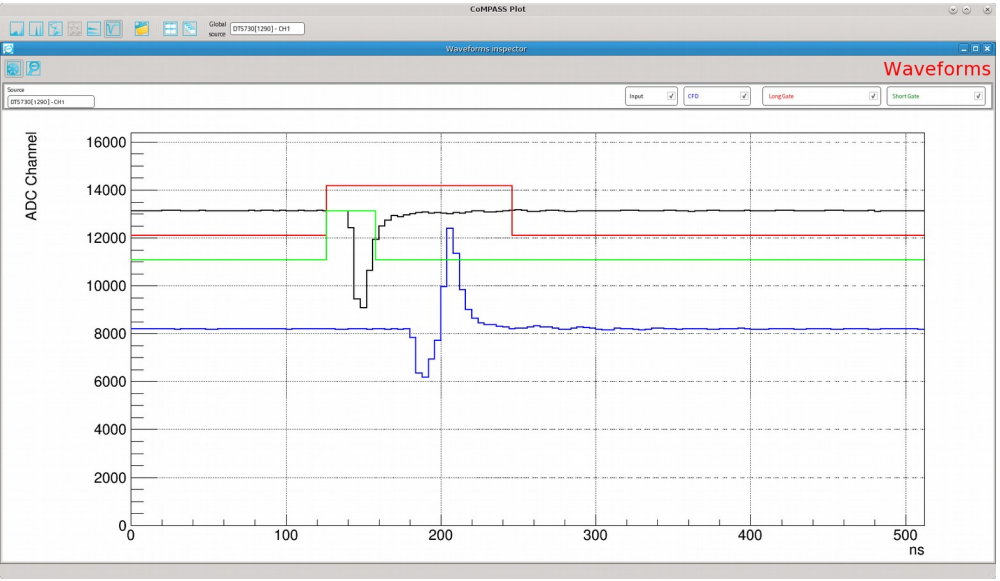
www.caen.it

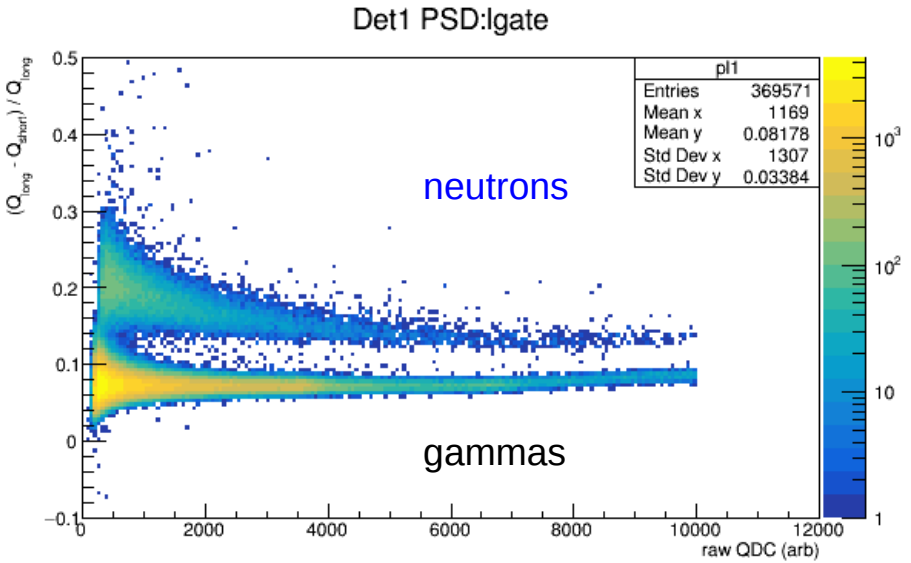
Neutron-gamma Discrimination

- **Caen Pulse Shape Discrimination firmware (DPP-PSD)**



B. Wan *et al*., Digital pulse shape discrimination methods for n-γ separation in an EJ-301 liquid scintillation detector, Chinese Physics C, Vol 39, Issue 11, 2015

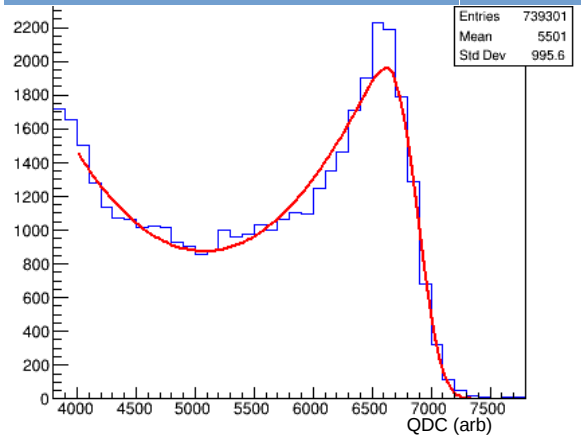




Calibration of light output – gamma sources

- **Compton Edges**

	E_γ [keV]	EC [keV]
Cs-137	661.6	477.3
Co-60	1173.2	963.4
Co-60	1332.5	1118.1
Co-60 (avg)	1252.9	1040.6
K-40	1460.8	1243.3
Tl-208	2614.6	2381.8



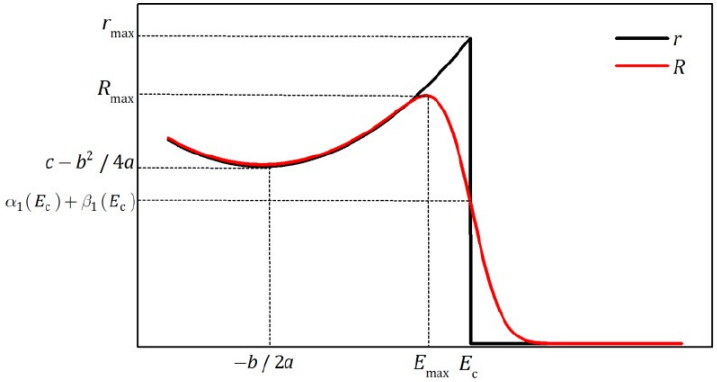
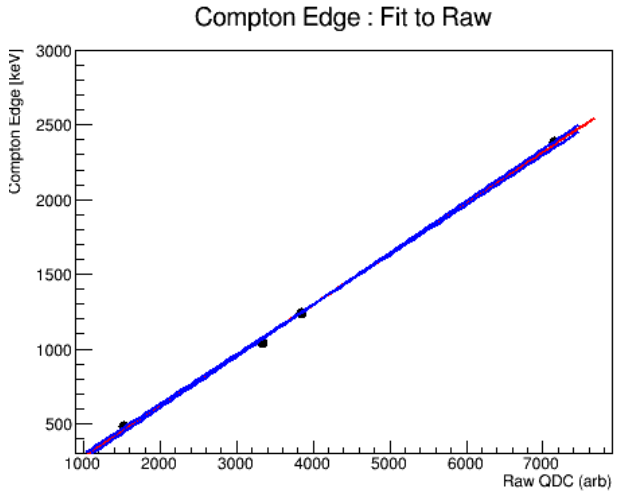
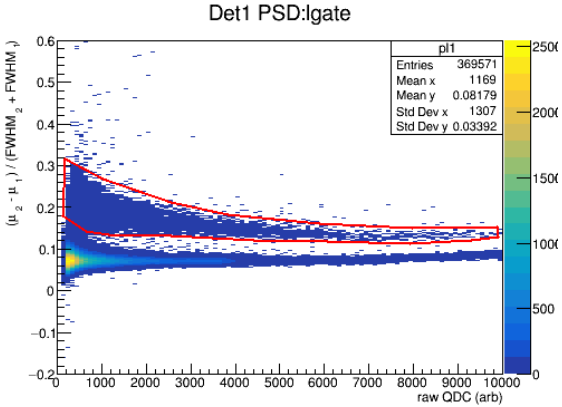


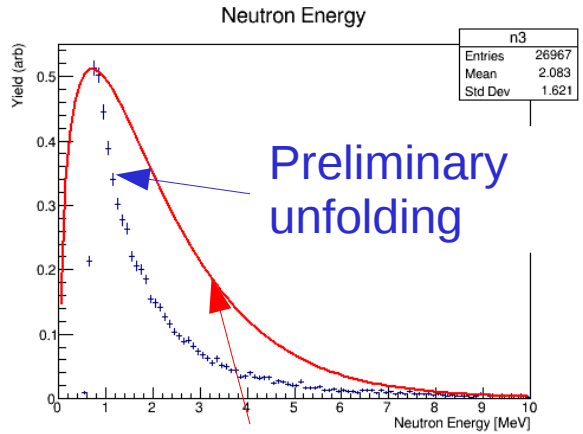
Figure 1. Ideal linear response function: $r(E)$, and the convolved response function: $R(E)$.

M.J. Safari *et al*., Differentiation method for localization of Compton edge in organic scintillation detectors, https://arxiv.org/abs/1610.09185

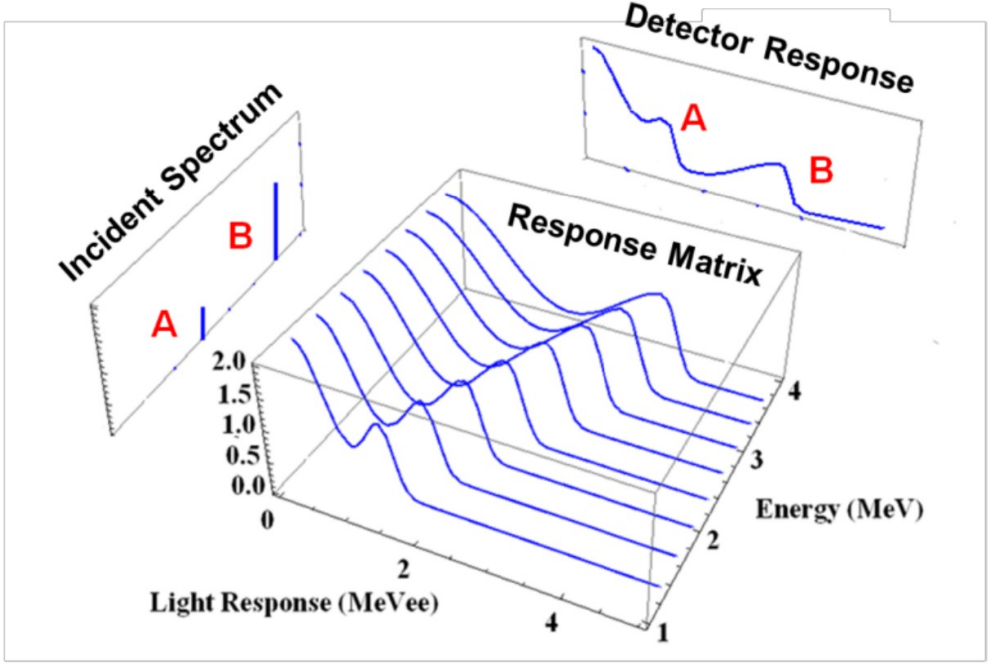


Neutron light deposited – ^{252}Cf





$$N(E) = \sqrt{E}e^{-E/T}; T = 1.43\text{MeV}$$



Michael T. Febbraro, University of Michigan dissertation, 2014

J. W. Boldeman, D. Culley, and R. Cawley, “The Fission Neutron Spectrum from the Spontaneous Fission of ^{252}Cf,” *Transactions of the American Nuclear Society* 32, 733 (1979).

W. P. Poenitz and T. Tamura, “Investigation of the Prompt Neutron Spectrum for Spontaneously-Fissioning ^{252}Cf,” Proc. Int. Conf. Nucl. Data Sci. Techno., Antwerp, Belgium, Sept. 1982, p. 465.

Research Approach

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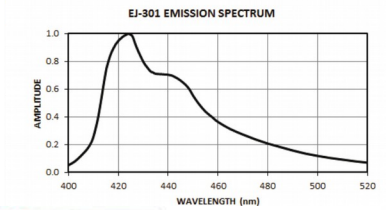
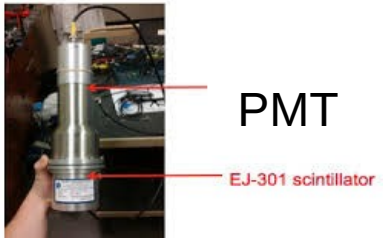
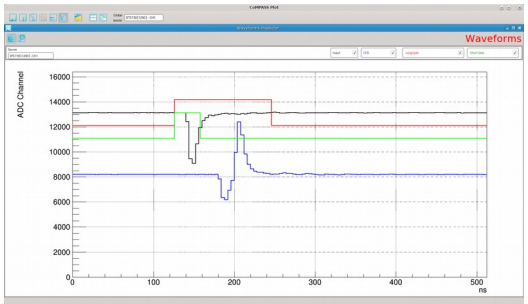




- **Caen Pulse Shape Discrimination firmware (DPP-PSD)**



www.caen.it

Caen DT-5730 desktop digitizer